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Committee on the Peaceful Uses of Outer Space

International cooperation in the peaceful uses of outer space: activities of Member States

Note by the Secretariat*

Addendum

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* The present document contains replies received from Member States between 15 December 2001 and 15 March 2002.

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II. Replies received from Member States

Canada

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1. The year 2001 has proved highly successful for the Canadian Space Agency (CSA), with the first ever Canadian extra-vehicular walk performed by Canadian astronaut Chris Hadfield, who delivered the Canadian robotic arm to the International Space Station (ISS). Further accomplishments were realized in a variety of fields, including the atmospheric sciences, robotics, international cooperation and microgravity research. CSA also saw the retirement of its seven-year President, W. M. (Mac) Evans, and the appointment of a new President, Marc Garneau.

2. CSA continues to pledge its commitment to promoting international cooperation in the peaceful uses of outer space and ensuring the continuity of social and economic benefits from space science and technology. The following provides a brief overview of the main Canadian activities in the space sector for 2001 and the activities planned for 2002. Readers are invited to consult the CSA web site for additional information at <http://www.space.gc.ca>.

1. International Space Station

(a) Prince of Asturias Award

3. In October 2001, the ISS partners were honoured with the 2001 Prince of Asturias Award for International Cooperation. The Prince of Asturias Foundation granted this award in recognition of the efforts made "to achieve international cooperation that have been necessary to turn this enormous orbiting laboratory for scientific research for a greater understanding of our planet into a reality". The selection of candidates for the Award for International Cooperation is based on the work of an individual, group or institution which contributes in an exemplary and significant way to promoting mutual understanding, progress and brotherhood among nations. CSA is proud to be a partner in the ISS project, together with Europe, Japan, the Russian Federation and the United States of America.

4. This undertaking represents the largest international science and technology project of all time. Once completed, the 450-ton space station will be a world-class research centre, providing a platform for advances in sciences and technology 400 km above the Earth. Its construction began in orbit in 1998 and successive crews of astronauts from various countries have been living and working on board since November 2000. Canada remains committed to its contribution to the station and will actively seek to help its partners in finding a mutually satisfactory solution to the current financial challenges.

(b) Hoffman Reflex experiment

5. How humans react to living in space for long periods of time was the subject of the first Canadian experiment on board ISS. The Hoffman Reflex experiment may lead to a better understanding of exercise requirements for astronauts during extended space flights. It may also lead to improvements in managing balance

disorders on Earth, particularly in the elderly. The Hoffman Reflex experiment examines changes in spinal cord excitability, an important element in the reflexes that keep people upright when they trip on the carpet or slip on ice. This is believed to decrease during long-duration space flight. The Hoffman reflex technique is similar to the "knee tap" test in a doctor's office, but replaces the doctor's hammer with an electrical stimulus to the nerve coming from the muscle and measures muscle activity electronically, providing far more accurate results.

6. The experiment was performed over a period of several months. Its subjects were the three ISS Expedition Two crew members and one of the Expedition Three crew. The experiment was performed at various intervals before, during, and after the flight. The CSA Payload Mission Support Centre, based in Saint-Hubert, provided ground support for Canada's Hoffman Reflex experiment, which was carried out three times on ISS in 2001 (in March, August and December). As stated by one of the prominent scientists (Mr. Watt, of McGill University), "so far, the results indicate that spinal cord excitability falls quite rapidly in weightlessness. However, there also appears to be a partial recovery after several months. The first finding was expected, but the second is a bit of a surprise".

(c) Extra-vehicular activity radiation monitor

7. In December 2001, the innovative extra-vehicular activity radiation monitor (EVARM) experiment, developed by Thomson and Nielsen of Ottawa, was used to measure the amount of radiation astronauts receive during space walks. Such measurements had never been taken before. The results are expected to lead to a better understanding of radiation exposure in space and to better planning of future space walk activities. The technology behind EVARM is already being used on Earth to monitor the radiation exposure of health-care professionals and patients during cancer treatments. In order to measure radiation levels during the space walk portion of a mission, small electronic badges were placed inside astronaut extra-vehicular activity (EVA) suits. The devices record the amount of radiation reaching various locations on an astronaut's body while he or she works outside the shuttle or ISS.

(d) Chris Hadfield takes a space walk and delivers the robotic arm to ISS

8. In April 2001, Canadians proudly watched as Canadian astronaut Chris Hadfield was launched in the space shuttle Endeavour to travel to ISS to deliver another piece of the Canadian contribution to this international initiative and to take the first space walk ever by a Canadian. Canadarm2 is critical to the successful assembly of ISS, as it acts as a "construction crane" to build the station in space, and will be used on virtually every assembly mission. Canadarm2 is the major element of the Mobile Servicing System, Canada's contribution to ISS. This next-generation robotic arm was built under the guidance of MD Robotics in Brampton, Ontario. Companies from all regions of Canada participated in building Canadarm2. Various connection devices will be installed at intervals on the station's external structure, allowing the arm to flip end-over-end to reach different anchor points. In addition to this feature of Canadarm2, its increased flexibility will allow the new arm to perform complex robotic manoeuvres beyond the reach of the original Canadarm.

2. Earth observation

(a) RADARSAT-1

9. RADARSAT-1, Canada's first commercial remote sensing satellite, successfully completed its sixth year in space in November 2001, having captured more than 220,000 images. Since its launch on 4 November 1995, RADARSAT-1 has completed more than 30,000 orbits around the Earth and travelled almost 1.3 billion km, greatly exceeding its nominal five-year lifetime. Its unique set of instruments, capable of monitoring our planet day and night in all weather conditions, has established an unparalleled international reputation and standard in Earth observation. Designed initially for frequent repeated surveillance of the entire Arctic region, the RADARSAT-1 mission has provided useful information in the fields of agriculture, cartography, hydrology, forestry, oceanography, ice studies and coastal monitoring to nearly 600 clients and partners from almost 60 countries.

(b) Global climate change

10. In a joint project between CSA and the National Aeronautics and Space Administration (NASA) of the United States, scientists are receiving assistance from images produced by RADARSAT-1 in determining the rate and extent of global climate change in Antarctica. For this mission, the CSA RADARSAT-1 satellite trained its imaging radar on the outer half of the continent twice during each of three consecutive 24-day periods, ending on 14 November 2001. Precise navigation and the data from the six passes made it possible to create detailed topographic maps and to measure the speed of the moving glaciers.

11. Early analyses show that in just three years the Amery Ice Shelf has advanced 5 km, while the Shirase Glacier, located in the Indian Ocean sector of the continent, has retreated 12 km. Scientists are seeking to understand whether this variability is due to the forces of external climate on the great ice sheet or due to natural and episodic instabilities that arise from the forces that control complex glacier flow. The new velocity measurements from this second completed mission will help answer these questions. The mission not only provides a snapshot of how the ice moves, but also provides important new insight into how and why the ice sheet is changing. By measuring the extent and velocity of the moving ice and estimating its thickness, scientists can estimate how much ice may be lost into the ocean from the Earth's largest storehouse of freshwater. These calculations are important for understanding Antarctica's contribution to the present rate of sea level rise of about 2 mm a year.

(c) Interferometric synthetic aperture radar (INSAR)

12. RADARSAT-1 has proven useful for a variety of applications, including interferometric synthetic aperture radar (INSAR) data. In April 2001 RADARSAT International (RSI) and CSA opted to maintain the RADARSAT-1 satellite in a +/-2 km orbit constraint, which reduced the nominal +/-5 km orbit constraint and allowed clients to use RADARSAT-1 data for interferometric applications. RADARSAT-1 is currently the only sensor available that can collect accurate INSAR data. INSAR applications include mapping and monitoring changes in elevation or movement on the Earth's land or ice surface (as subtle as centimetres or less), as well as the creation of highly detailed and accurate digital elevation

models. INSAR can be used to monitor changes in man-made structures, land subsidence and tectonic movement.

(d) Country mosaics

13. RADARSAT-1 has also been used to create mosaics of various countries, the latest being that of Australia, completed in July 2001. The Australia mosaic is the result of a compilation of 165 images captured from mid-November 2000 to mid-February 2001, which successfully demonstrate the timely and detailed observation capacity of RADARSAT-1 and the expertise of the Canadian partner RSI. These mosaics can be useful in detecting changes or can be used as reference points to monitor changes in urbanization, desert encroachment and coastline morphology.

3. Space science

(a) Measurements of Pollution in the Troposphere (MOPITT)

14. Professor James Drummond of the University of Toronto, Principal Investigator for the Measurements of Pollution in the Troposphere (MOPITT) instrument of the Canadian Space Agency, unveiled unique new data on global air pollution during a press briefing in May 2001 at the American Geophysical Union annual meeting in Boston, Massachusetts, United States. Understanding where pollution comes from, how it is transported and where it is destroyed is very significant for anyone studying the subject of atmospheric science. The MOPITT instrument was launched in December 1999 on board the Terra satellite of NASA as part of an international Earth observation mission involving Canada, Japan and the United States. The instrument is designed to track two pollutants, carbon monoxide and methane, from space. It has completed a year of data collection and is providing the first view of the global distribution of these pollutants. Using modelling and animation, a film can be produced showing the transport of pollution around the globe. Large production regions can be seen around the equator, associated with grass and forest fires, the transport of the pollutants over vast distances across the oceans, from Africa to South America, from South America to Southern Africa and then on to Australia. In the northern hemisphere we can see sources from forest fires, such as the ones in North America last summer, and industrial activity flowing around the globe.

(b) Science Satellite (SCISAT)

15. Two instruments designed to study and gather information on the chemical processes occurring in the ozone layer approximately 8 to 50 km above the Earth's surface have been chosen to fly on Canada's scientific satellite, SCISAT-1. The first instrument, called the atmospheric chemistry experiment (ACE), will focus on the Arctic environment, studying the likely effects of climate change such as melting permafrost and the retreat of permanent ice packs that have already been observed in this fragile environment. The second instrument, Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation (MAESTRO), will aid in the satellite's overall mission of increasing the understanding of the chemical processes involved in the depletion of the ozone layer.

(c) Odin and Optical Spectograph and Infra-Red Imaging System (OSIRIS)

16. Sweden's Odin satellite was successfully launched from Svobodny, Russian Federation, in February 2001, on a dual-purpose mission, to study ozone depletion in the Earth's atmosphere and to search for water and oxygen in interstellar space. CSA provided the Optical Spectrograph and Infra-Red Imaging System (OSIRIS) instrument, which will provide detailed data relating to ozone depletion, especially with respect to the situation at high latitudes, including Canada. Odin is the result of an international collaboration effort between Canada, Finland, France and Sweden. The astronomical objective of the mission is to study the physics and chemistry of interstellar space by searching for water and oxygen molecules. These molecules are crucial clues for improving our understanding of comets, giant molecular clouds and nearby dark clouds, the deep atmospheres of Jupiter and Saturn and the formation of stars in nearby galaxies. CSA provided a cryogenic cooler to keep Sweden's Sub-Millimetre Radiometer (SMR) instrument at a cool -175 degrees Celsius, enabling it to register signals from distant stars. When not pointed at the stars, this instrument will work in conjunction with OSIRIS to provide complementary data for ozone research. The Natural Sciences and Engineering Research Council of Canada is also a participant in this programme, providing ground-based scientific support as well as the analysis of data coming from the mission.

4. Communications

(a) Teleservices

17. Recent advances in telecommunications technology and especially in telemedicine services have dramatically improved the quality of life for citizens living in Canada's remote communities in Labrador. Using the network provided by the consortium responsible for the Remote Community Services Telecentres project, these new technologies are achieving important milestones in health-care delivery for citizens living in rural communities where access to specialized care is often sporadic and where people must travel great distances to see a specialist. Leading-edge technologies used for telemedicine purposes were developed through a project funded partly by CSA and through a partnership between the Government of Canada and the European Space Agency (ESA). Telesat Canada, Futureworks, QTECH Hybrid Systems, ColabNet, Telehealth and Education Technology Resources Agency (TETRA) and Communications Research Centre Canada have also collaborated on this project.

18. In March 2001, Telesat Canada and CSA launched a new initiative that will dramatically improve emergency medical response to marine vessels travelling in Canadian waters. The Marine Interactive Satellite Technologies (MIST) programme is the third in a series of progressively successful multimedia satellite-based initiatives led by CSA and Telesat that are providing vital services to Canadians in remote regions of the country. The MIST project equips marine vessels with high-speed mobile satellite communication terminals that can link patients or on-board medical staff with medical experts on shore. Along with use for emergency purposes, the terminals can be used by passengers for everything from checking their office e-mail to booking a hotel at their destination port.

(b) Advanced Relay and Technology Mission Satellite (ARTEMIS)

19. Two prominent Canadian companies have contributed essential elements to the communications satellite, ARTEMIS, launched by ESA on 12 July 2001, from Kourou, French Guiana, on board an Ariane 5 rocket. ARTEMIS shared the Ariane 5 launch with another satellite, the Japanese direct broadcasting satellite BSat-2B. COM DEV International supplied the Ka-Band Output Multiplexers to the satellite, a unit consisting of six telecommunications channels. PerkinElmer Optoelectronics provided the R/F Front-end module (RFE), an important component of the Satellite Interoptical Link Experiment equipment installed on board ARTEMIS.

5. Activities for young people

20. CSA informs the general public and especially youth about the activities Canada conducts in space and the potential benefits they can engender on Earth. Maintaining interest in the science and technology fields today will ensure adequate levels of representation from our youth in later years as they enter the workforce. As part of these efforts to maintain youth's interest, various live broadcasts from ISS directly to classrooms around the country have been taking place, especially when Canadian astronauts are on board ISS. CSA has also devised various studies in which students can actively participate. One example is an experiment in which tomato seeds are grown simultaneously on the space shuttle or ISS and in the classroom. Students will then be called upon to analyse the two sets of samples.

21. Two Canadian university students have been awarded a prestigious scientific scholarship to participate in a research and training programme at the John F. Kennedy Space Center of NASA. The scholarship allows the two university students to participate in an intensive six-week research programme at the Space Center, in Florida, with 25 other students in life sciences, bio-engineering and other related fields. During the course of this programme, the students will take part in the conceptualization, preparation, pre- and post-flight testing, data analysis and report preparation phases of simulated space flight experiments and in NASA life sciences research.

22. On 28 August 2001, 75 students, educators and scientists participating in the Students on Ice expedition to the Arctic viewed the continent from space with the help of RADARSAT-1. The students, who are learning about the issues affecting the continent, used high-resolution RADARSAT-1 images to pinpoint the location of their expedition vessel while learning how to interpret images from space. This will enable them to better understand the physical environment of the Arctic, conduct sea-ice investigations and monitor early warning signs of climate change in that area.

23. On 9 October 2001, CSA astronaut Robert Thirsk launched a unique space-based e-learning initiative, known as Space for Species, with a group of grade 6 students from Riverview Alternative School in Ottawa. Space for Species is an Internet-based project that provides students from across the nation with access to space-based technology to help them learn about species conservation. The project is being led by CSA, the Canadian Wildlife Service of Environment Canada, the Canadian Wildlife Federation and the Canada Centre for Remote Sensing of Natural Resources Canada. The goal is to use space-based technology to connect students

with their environment and with each other. Students become actively engaged in the struggle of wildlife as they become engaged in tasks that include monitoring the complete migratory cycle of the animals online and learning about the threats to their existence.

6. Space-based services to mitigate natural disasters

24. Since its activation in November 2000, the Charter on Cooperation to Achieve the Coordinated Use of Space Facilities in the Event of Natural or Technological Disasters (International Charter on Space and Major Disasters), originally a tripartite collaboration between Canada, Europe and France, has been activated 13 times. Various countries are now indicating their interest in joining this voluntary effort to provide satellite-based images to rescue organizations on the ground, including India and the United States. The Charter is open for signature by space agencies and satellite operators anywhere in the world. All partners undertake to cooperate on a voluntary basis, with no exchange of funds between them.

25. In January 2001, responding quickly to support rescue efforts converging on El Salvador, member space agencies of the Charter dispatched their Earth observation satellites to capture images of the devastation caused by the earthquake. In response to a request received on 15 January through the French Civil Protection Agency, the Charter was activated to help the international rescue teams on the ground in El Salvador. The satellites of the rescue constellation were re-tasked to support the emergency. These included the French space agency's optical series satellite (SPOT), the synthetic aperture radar satellites of ESA (ERS-2) and the Canadian Space Agency (RADARSAT-1). Up-to-date maps and information obtained from archived and newly acquired images were forwarded to the rescue authorities as soon as they were available. Positioning, operation and image capture were coordinated by the Charter partners.

26. In May 2001, as part of the efforts made to assist rescue teams dealing with the most severe floods that Eastern Siberia, Russian Federation, had seen in a century, RADARSAT-1 of CSA joined forces with other Earth observation satellites to capture images of the Lena River. Those images undoubtedly helped Russian Federation rescue teams in the region of Yakutia by enabling them to send resources where they were most needed.

7. Awards

(a) John H. Chapman Award of Excellence

27. In 2001, W. M. (Mac) Evans, then President of CSA, and other members of the aerospace sector honoured Valentine O'Donovan for his exceptional contribution to the Canadian Space Program by presenting him with the John H. Chapman Award of Excellence. The selection of Mr. O'Donovan as the second recipient of the annual award is a testament to the leadership, expertise and excellence that he has inspired among colleagues in the Canadian space industry over the years. Mr. O'Donovan was recognized as a champion of innovation, expertise and excellence. He is the founder and currently Chairman of COM DEV International, a leading global designer, manufacturer and distributor of space products and subsystems. Mr. O'Donovan is renowned for his expertise in digital communication and the design of advanced microwave payloads for communications satellites. Under his

direction, COM DEV International has enjoyed a successful association with CSA, contributing to the advancement of the Canadian Space Program. Among those projects were the International Mobile Satellite Communications Program and MOPITT, Canada's first major instrument to measure, from space, the pollution of the Earth's atmosphere, which was a joint project with the University of Toronto.

(b) C. D. Howe Award

28. W. M. (Mac) Evans, then President of CSA, received the prestigious C. D. Howe Award in 2001 for his achievements in the fields of planning, policy-making and overall leadership in Canadian aeronautics and space activities. Mr. Evans received the award at the annual Awards Dinner of the Canadian Aeronautics and Space Institute (CASI), held on 1 May in Toronto. The award is a tribute to Mr. Evans's contribution to the establishment of CSA, as well as his ongoing leadership in the development of the Agency's long-term space plan. It was presented to Mr. Evans by the President of CASI, David G. Zimcik, Group Leader in Aeroacoustics and Structural Dynamics at the National Research Council of Canada. The award recognized Mr. Evans's role over the previous 33 years as a central player and key architect in all aspects of the Canadian Space Program. The C. D. Howe Award was introduced in 1966 and is presented for exceptional personal performance in the fields of planning, policy-making and overall leadership in Canadian aeronautics and space activities.

(c) Public Service Medal

29. Mr. Evans was also awarded the Distinguished Public Service Medal of NASA in 2001, the highest honour conferred to non-Americans, in a private ceremony held in Washington, D.C., on 31 October. NASA Administrator Dan Goldin presented Mr. Evans with the medal in recognition of his outstanding efforts to promote partnerships between the Canadian and United States space programmes. During a career that spanned 35 years of dedication to the Canadian Space Program, Mr. Evans was instrumental in negotiating Canada's role in ISS. He was also a key architect of the Canadian Space Program, the RADARSAT Program, which gave rise to Canada's first remote-sensing satellite, the Canadian Astronaut Program, as well as the legislation that created CSA. Appointed President of CSA in 1994, Mr. Evans retired from the Canadian Public Service on 21 November 2001.

(d) David Florida Laboratory receives International Organization for Standardization 9002 certification

30. The David Florida Laboratory of CSA, Canada's national facility for the assembly, integration and environmental testing of satellites and other space-based hardware, received ISO 9002 certification in 2001. ISO certification is an internationally accepted technical standard for managing all processes that affect an organization's ability to meet client requirements for quality service. ISO 9002 certification demonstrates the David Florida Laboratory's commitment to providing its clients with the best service possible.

8. Activities planned for 2002

(a) International Space Station

31. Another of Canada's contributions to ISS, the Mobile Base System (MBS) is scheduled for a May 2002 launch. MBS provides a movable work platform and storage facility for astronauts during space walks. Since it has four grapple fixtures, it can serve as a base for both Canadarm2 and the Special Purpose Dexterous Manipulator (SPDM) simultaneously. MBS will slide along a track system mounted along the entire width of ISS, thus facilitating the construction and maintenance of the facility.

32. SPDM is expected to be launched to go to ISS in 2003 or 2004. It is an essential tool for maintaining and servicing ISS. With its dual-arm design which provides added flexibility, it will remove and replace smaller components on the ISS exterior, where precise handling is required. It can automatically adjust its movements when sensing various forces and movements on the payload, thus ensuring smooth manipulation.

(b) Canada's first microsatellite

33. The Microvariability and Oscillations of STars (MOST) experiment will comprise Canada's first microsatellite, weighing only 50 kg. MOST will be the world's smallest astronomical space telescope, capable of measuring the ages of stars in our galaxy and perhaps even unlocking the mysteries of the universe. The microsatellite is scheduled for launch in October 2002.

(c) Launch of SCISAT-1 and the atmospheric chemistry experiment in 2002

34. Work is under way on SCISAT-1 and its scientific mission, ACE, which will study ozone depletion in the atmosphere. SCISAT-1 will improve our understanding of the chemical processes that control the distribution of ozone in the Earth's atmosphere, especially at high altitudes, with particular emphasis on the processes occurring over Canada and the Arctic.

(d) Environmental Satellite (ENVISAT)

35. The Environmental Satellite (ENVISAT) is the follow-on to the earlier Earth observation satellites of ESA, ERS-1 and ERS-2, to which Canada made significant contributions. ENVISAT will ensure the continuity of radar images and will be used extensively by Canadian users, together with data provided by our own RADARSAT-1 and soon RADARSAT-2. The satellite is scheduled for launch in early 2002 from Kourou, French Guiana.

(e) Ongoing work on RADARSAT-2

36. RADARSAT-2, Canada's next-generation Earth observation satellite, currently under construction by MacDonald Dettwiler and Associates and scheduled for launch in early 2003, will further increase Canada's ability to provide precise imaging to meet the evolving needs of clients, while fulfilling its commitment under the International Charter on Space and Major Disasters to relief agencies and disaster-management organizations.

France

[Original: French]

1. The space activities of France aim principally at responding to major developments in the international environment. The objective of the Centre national d'études spatiales (CNES) in the coming years is therefore to ensure that the results of space activities contribute further to serving the needs of society. With regard to environmental monitoring and natural disaster management, for example, the emphasis will be placed on improved utilization of existing means and the development of future facilities for Earth observation.

1. Key events in major space programmes in 2001

(a) Space transport

2. The Ariane launcher is currently being upgraded so that it can lift 10 tons into geostationary orbit with multiple mission capability through its reignitable upper stage. The new capacity will be available from 2002 onwards.

(b) Earth observation

(i) SPOT 5 Earth observation satellite

3. Qualification tests on the SPOT 5 satellite are proceeding as planned and it is scheduled for launching in April 2002. It is equipped with a high-resolution geometric instrument and a new stereoscopic imaging system which will permit three-dimensional modelling of the target terrain. The various applications to which these instruments can be put makes them indispensable tools for improving forecasts and the processing of data connected with environmental monitoring and security.

(ii) Demeter satellite

4. The Demeter satellite is the first of the Myriade range of microsatellites developed by France (through CNES) for scientific or technology demonstration missions. It is designed to measure electromagnetic fields emitted during earthquakes and will be used for monitoring volcanic and seismic events. The payload, which is currently being completed, will be delivered in June 2002, for launch at the end of 2003.

(iii) Infrared Atmospheric Sounding Interferometer

5. The Infrared Atmospheric Sounding Interferometer (IASI) instrument will be used in meteorological operational (METOP) satellites, its advanced technology permitting measurements of temperature and humidity with a vertical resolution of 1 km and an accuracy of 1 degree K and 10 per cent humidity. The first flight model is scheduled for delivery in 2003.

(iv) Pléiades minisatellites

6. A constellation system for Earth observation consisting of two optical minisatellites (Pléiades) and four radar minisatellites (Cosmo-Skymed) is scheduled for launch from 2006 onwards. This multi-sensor system is the result of an

intergovernmental Earth observation agreement between France and Italy, designed in particular to meet the needs expressed by users in fields such as cartography, agriculture, forestry, marine applications and land use.

(v) Jason minisatellite

7. The minisatellite Jason, which uses the first Protéus platform, is designed for oceanographic observation and was successfully launched on 7 December 2001. It will take over from TOPEX/POSEIDON, data from which are utilized by more than 400 users. These two projects are the result of cooperation between France and the United States. The satellite was placed in its target orbit with remarkable precision. All control operations indicate that the platform, payload and ground station are functioning perfectly.

(vi) Megha-Tropiques minisatellite

8. The minisatellite Megha-Tropiques was developed by France in cooperation with India and is designed to study the water cycle and heat exchanges in the intertropical region with a view to helping forecast cyclones. The satellite consists of a Protéus platform (developed by CNES) and a payload comprising three instruments: MADRAS (multi-frequency microwave scanning radiometer), developed by the Indian Space Research Organization (ISRO), and Saphir (microwave humidity-sounding radiometer) and Scarab (energy-measuring instrument), both supplied by France.

(c) Navigation and telecommunications

(i) Galileo navigation system

9. The Galileo navigation system, which is compatible with and complementary to the Global Positioning System (GPS) of the United States, is intended primarily for a broad user community. Given the accuracy, integrity and permanent availability of the signal, its applications in the public interest will be extensive and could include aircraft navigation, location positioning within road, rail and maritime transport systems, rescue and all applications connected with health and humanitarian aid. The project is the result of an initiative by the European Union and ESA. CNES and French industry are involved in the definition phase and France is one of the principal financial contributors.

(ii) Stentor technology demonstration satellite

10. This technology demonstration satellite will be launched in July 2002. It will carry technologies that have been qualified on the ground such as plasma propulsion, lithium-ion batteries and high-voltage travelling wave tubes.

(d) Space exploration

(i) Mars exploration

11. The Mars exploration programme is a French-United States initiative. The French part of the programme, called Mars Premier (Mars sample return and experiment network installation programme), consists of two main segments:

(a) The development and operation of an orbiter that will collect ground samples from Mars;

(b) The deployment on Mars of four landers to study the geophysics and climatology of the planet.

12. In addition to these two missions, France will provide the scientific payloads for the orbiters and landers. The sample return mission is scheduled for 2011 at the earliest, after the necessary validation stages to commence in 2007. The French orbiter mission in 2007 will transport and put in place four landers designed to study the deep internal structure of Mars, the sites of possible water or ice reservoirs, geological and mineralogical structures at the landing sites and atmospheric measurements.

(e) Manned flights

13. The French astronaut from ESA, Claudie Haigneré, took part in a French-Russian mission on board the International Space Station from 21 to 31 October 2001. The mission involved a dozen scientific experiments in different fields (biology, physiology, physical sciences and Earth observation).

2. Space technology application programmes

(a) Global Monitoring for Environment and Security

14. The Global Monitoring for Environment and Security (GMES) project is a joint initiative by the European Commission, ESA, national space agencies and European manufacturers. Its aim is to meet the needs of public welfare and the demands of environmental and security policies.

15. GMES involves two principal fields:

(a) Implementation of international environmental treaties;

(b) Prevention and management of natural or industrial risks. On this point, France is the originator of an international charter concluded by CNES and ESA, which allows for the coordinated use of space facilities in the event of disasters. The Canadian and Indian space agencies, CSA and ISRO, have joined this initiative, and the National Oceanic and Atmospheric Administration (NOAA) of the United States is also associated with it.

16. The French Earth observation programmes are part of the GMES initiative.

(b) Réseau Terre et Espace (Earth/Space Network)

17. An initiative of the French Ministry of Research, Réseau Terre et Espace (Earth/Space Network), will help to improve the development of space technology applications in the public interest. It is designed to develop, through cooperation between industry and scientists, new service projects using, inter alia, data from space and space-based telecommunications and positioning facilities for natural and industrial risk management, precision agriculture and natural resource management (particularly water and forests), and also for emerging fields such as space-based epidemiology.

18. The main thrusts of the Network are:

(a) Management of renewable resources, the environment and landscape;

(b) Planning of transport infrastructure and security;

(c) Health and risks;

(d) Education.

A dozen or so projects involving these areas were inaugurated in 2000 and 2001.

(c) Prevention and prediction of floods using space technologies

19. One of the first projects in the Earth/Space Network is prevention and prediction of floods using space technologies (PACTES), whose aim is to establish an optimized comprehensive approach to the management of flood risks through the use of existing and future space-based systems. Industry, the scientific community, service enterprises and end-users have been involved right from the planning stage.

(d) Telemedicine

20. Telemedicine is part of the "health and risks" component of the Network. Studies carried out in France in recent years show that space-based structures have been used for medical purposes in the following fields:

(a) Teleconsultation, in which a medical team or expert in a hospital gives assistance in diagnosis and treatment to a doctor with a patient in an isolated region;

(b) Tele-epidemiology using space-based systems that provide data on local conditions such as weather, vegetation and hydrological conditions following a natural disaster. These data, combined with human and animal clinical data, make it possible to predict and therefore prevent epidemics. CNES is conducting a number of campaigns in these two fields in different parts of the world: Antarctica, Cambodia, Senegal, South America and, in the near future, India;

(c) Remote assistance to high-risk patients living in isolated conditions. CNES is currently running the Disaster Emergency Logistic Telemedicine Advanced Satellite Systems (DELTASS) project for ESA. This project will allow the use of a transportable telemedicine system to transmit information from a disaster site, particularly where telegraphic communications have been damaged, to a hospital and medical team.

21. In addition, Liaison, Education, Diagnosis and Assistance (LEDA), a satellite-based telemedicine system for developing countries, has just been set up by a number of French organizations including CNES, the Institut Pasteur and the Institute for Space Medicine and Physiology (MEDES).

22. From February 2002 onwards, LEDA should make it possible for health professionals in developing countries or working abroad on mission to communicate by means of a suitcase satellite or standard Internet connection, if there is one locally, with an information centre managed by *Médecins du Monde* at the Institut Pasteur in Paris. Health professionals from *Médecins du Monde* working in remote areas will thus be able to communicate with medical experts, access databases or obtain remote interactive assistance for medical diagnosis.

23. Remote training and re-training are also provided for by the system set up by this group of scientific institutions. The non-governmental organizations Douleurs

sans frontière (Pain without frontiers), Formation professionnelle développement and Santé pathologie cytologie développement are also participating in the project.

Malaysia

[Original: English]

1. Introduction

1. Under its Third Malaysian Long-Term Economic Plan, space science and technology was identified as one of the main components of science and technology research and development which will provide input to the development and advancement of economic growth in Malaysia in the coming decades. Malaysia is committed to the development and advancement of space science and technology.

2. Under the Plan, a National Space Agency that will administer and coordinate all activities related to space will be established.

2. Remote sensing

3. Under its National Remote Sensing Programme, Malaysia has embarked on the National Resources and Environment Management (NAREM) project, which is expediting the operational use of remote sensing and related technologies such as geographical information systems and satellite-based positioning systems. NAREM is currently dealing with national issues such as integrated coastal zone management, integrated highlands and islands management, land capability classification, natural disaster management and the continuous monitoring of protected areas.

4. The development of satellite remote sensing in Malaysia, which is led by the Malaysian Centre for Remote Sensing (MACRES), is envisaged to involve three stages, namely the user, ground and space segments. MACRES is now establishing the MACRES Ground Receiving Station System to receive real-time satellite remote sensing data in order to cater to the demand for up-to-date information for more effective natural resources and environmental management.

3. Satellite technology

5. Malaysia's first microsatellite, TiungSAT-1, has proven that cooperative programmes offer opportunities for engineers and scientists to be trained in satellite design, manufacturing, testing, launch and operations at reduced development time and costs.

6. Malaysia is also now stepping further forward into the development of small satellite technologies by proposing a near-equatorial low-Earth orbit satellite constellation, which would consist of an affordable constellation of small satellites to provide Earth observation and digital communications services that would best meet the requirement of multiple users in Malaysia.

7. As the first step, Malaysia, through its wholly Government-owned company, Astronautic Technology (ATSB) is presently co-developing a medium-sized aperture camera (MAC) and a medium-sized aperture camera satellite (MACSAT) with

Satellite Research Initiatives of the Republic of Korea. MAC will be able to provide 2.5 m panchromatic and 5.0 m multispectral resolution, and the combined payload of MAC and MACSAT is engineered to be approximately 200 kg.

8. To overcome the problem of infrequent and expensive launch opportunities for small satellites to the low equatorial orbit, ATSB is now collaborating with AeroAstro of the United States in developing a novel concept of Small Payload Orbit Transfer (SPORT), which can perform a variety of orbit transfer operations to fit any mission using a patented atmospheric braking technique pioneered by NASA.

9. ATSB is also developing a ground station to be used as a telemetry, tracking and control and receiving station for SPORT, MACSAT and future satellites. International cooperation with countries within the equatorial belt such as Brazil and Indonesia is being initiated to synergize space activities and their development.

4. Telecommunications

10. Malaysia's first regional satellite system, called the Malaysia East Asia Satellite (MEASAT), which is owned and operated by Binariang Satellite System, is now planned to be extended to include MEASAT-3, -4, -5 and -6, in addition to MEASAT-1 and -2, to provide optimum coverage of the East Asian region.

11. MEASAT-3 will be situated at an orbital slot of 91.5 degrees east, together with MEASAT-1. It will carry 24 C-band and Ku-band transponders and have an approximate lifespan of 15 years.

12. MEASAT-4 is still under study.

13. MEASAT-5 will be located at an orbital slot of 93.5 degrees east, will carry 24 C-band transponders and have an approximate lifespan of 15 years. MEASAT-5 will be used for very small aperture terminal, data and Internet transmissions.

14. MEASAT-6 will be located at an orbital slot of 5.7 degrees east, will carry 24 C-band and 12 Ku-band transponders and will be used for telecommunications, Internet and direct-to-home services.

5. Meteorology

15. The meteorological satellite activities of the Malaysian Meteorological Service are focused on operational applications for weather forecasting, severe weather monitoring, volcanic ash cloud detection, hot spot (forest fire) detection and the use of vegetation indices for crop yield assessment. To support these activities on an operational scale, six medium-scale data utilization stations to receive GMS-5 satellite data and one high-resolution picture transmission station to receive NOAA satellite data are located within the meteorological facilities. Meteorological satellite applications continue to benefit from the principle of unrestricted and free dissemination of essential meteorological data by satellite operators.

16. A significant development in the meteorological satellite observation programme is the launching of the Multi-functional Transport Satellite (MTSAT-1R) in 2003 to replace the GMS-5 satellite. In anticipation of this transition from GMS-5 to MTSAT, Malaysia has formulated a long-term plan for a smooth changeover for its six MDUS medium-scale data utilization stations.

17. On regional cooperation in meteorological satellite applications and natural hazard monitoring, several projects such as capacity building for disaster management, monitoring of the monsoon and technology for inexpensive meteorological ground stations are in the development pipeline under the Regional Space Applications Programme for Sustainable Development (RESAP-II). Malaysia is actively participating in these regional cooperation activities.

6. **Education**

18. Courses in astronomy and astrophysics are conducted at the University of Malaya and the National University of Malaysia, which also offers courses at the postgraduate level and specialized undergraduate and postgraduate courses in telecommunications engineering. Courses in aerospace engineering, which cover selected aspects of astronautics, are offered by Technology University of Malaysia, Universiti Putra Malaysia and Science University of Malaysia.

19. Space science is a compulsory subject in schools in the sixth and ninth years. It is an important component of extra-curricular activities and school astronomy clubs abound in all parts of the country. Educational activities are also undertaken by amateur societies such as the Malaysian Planetary Society and the Astronomical Society of Malaysia.

20. The national planetarium in Kuala Lumpur, under the Space Science Studies Division, conducts courses for teachers and the public and organizes regular educational activities on space science for teachers, students, professionals and the public. It publishes magazines, books and brochures regularly.

Portugal

[Original: English]

1. Portuguese space policy is strongly influenced by its membership of the European Union and by its recent accession to international organizations related to space, namely ESA (1999) and the European Southern Observatory (ESO) (2000).

2. Following the accession to ESA in 2000, Portugal is now starting to participate in several ESA programmes. At the last ESA ministerial council meeting, held in Edinburgh on 15 November 2001, the United Kingdom of Great Britain and Northern Ireland, Portugal subscribed to a new optional programme on space exploration, called Aurora, and strengthened its participation in the Navigation and Communications programmes.

3. A team from the Portuguese Laboratory for High Energy Physics is a partner in the Extreme Universe Space Observatory collaboration, an ESA mission approved by the ESA Science Programme Committee and the Manned Spaceflight programme on February 2001. In May 2001, Portugal also joined the EDDI science data centre definition working group of the Eddington Mission of ESA.

4. To adapt Portuguese industries to ESA activities, an ESA/Portugal task force was established; it is planned to last for a six-year transition period. In 2001, 10 Portuguese private firms obtained contracts with ESA totalling 3.9 million euros.

5. Remote sensing is one space-related area that has been very active in Portugal. The remote-sensing community in Portugal is connected through the Portuguese Earth Observation Network, which is an Internet information service designed to promote the use of satellite imagery in Portugal, and which is integrated in the national system for geographical information network.

6. The use of remote sensing for environmental monitoring and management has increased in recent years. In addition to research activities, mainly funded by the European Commission and the Ministry of Science and Technology of Portugal, there are already several operational uses of satellite imagery in Portugal, such as mapping burned areas and irrigated areas.

7. In 2001, together with the European Commission, Portugal joined the Coordination of Information on the Environment (CORINE) land-cover programme. The main goal is to produce a national land-cover map on the scale 1:100,000 with 44 classes. This is the national contribution to the CORINE land-cover map to be produced for the whole of Europe before the end of 2003.

8. In the field of meteorology, Portugal is playing an active role in the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) network of satellite application facilities, which, along with the EUMETSAT central facilities, will constitute the future EUMETSAT application ground segments for the Meteosat Second Generation meteorological satellite system and the EUMETSAT Polar System. Portugal is the leader of the Satellite Application Facility on Land Surface Analysis (Land-SAF), which has been conceived to monitor land surface using satellite data.

9. In 2001, Portugal started the Prevention and Mitigation of Fire Hazard in Portugal (PREMFIRE) project, funded by ESA, whose main goal is to create a prototype of a fire risk management system for fire hazard prevention and mitigation using remote sensing and communications technologies. This system will be integrated into the existing national Internet network for disaster management.

10. In 2001, Portugal collaborated on the definition of GMES, which is a joint initiative of the European Union and ESA aimed at supporting Europe's goals regarding sustainable development and global governance. The ultimate goal is to establish, by 2008, an operational and autonomous European capacity for global monitoring of environment and security.

11. In 2001, several events related to space activities were organized in Portugal. The Seventh International Workshop on Digital Signal Processing Techniques for Space Communications, held from 1 to 3 October 2001, is one example.

12. Portugal has been giving special emphasis to education on space-related activities. In 1998, the Agência de Inovação started a programme to support the training of young engineers at ESA. Portugal is participating for the first time in a NASA educational project entitled The Space Experiment Module Program. Various types of experiments were programmed by 12 Portuguese secondary schools for the Space Shuttle Endeavour mission STS-108 of 5 December 2001.

13. In 2001, several research teams worked on proposals to define their work for the coming years. Portugal submitted three proposals for ESA-recognized cooperative laboratories to the Mars Express mission, proposals which were prepared after the Announcement of Opportunities Workshop that took place in

Lisbon in June 2001 on the second Mars Express and Bepi-Colombo missions. A research team from the University of Lisbon recently drew up a proposal to build and validate a near-infrared camera to be used in the Very Large Telescope of ESO, including a new system of multi-conjugate adaptive optics. It will be the first high-resolution wide-field-of-view camera that is using extended correction for atmospheric turbulence. This proposal has been approved by ESO and its financing is now under consideration by the Ministry of Science and Technology of Portugal.

14. A workshop on solar systems research in Portugal, organized together with ESA, was held in Lisbon on 7 and 8 March 2002. Portugal presently has seven young graduate trainees at ESA: four at the Research and Technology Centre for the European Space Agency, two at the European Space Research Institute and one at the European Space Operations Centre of ESA.

15. In March 2002, the Institute for International Scientific and Technical Cooperation and the European Centre for Space Law will organize a conference in Lisbon to promote and develop knowledge of law related to space activities.

16. A conference entitled Jupiter after Galileo and Cassini is being organized in Lisbon from 17 to 21 June 2002. This is a European conference supported by the European Union, ESA and local Portuguese institutions. Its main goal is to update the analysis of new data on the Jovian planets and discuss future data from the Cassini and Huygens missions and future scientific exploration of the outer solar system.

Slovakia

[Original: English]

1. The Government of the Slovak Republic decided on 13 September 2000, to support the participation of the Committee for Research and Peaceful Uses of Space, which is analogous to a space agency in other countries, and the research institutions of Slovakia in all activities of the Committee on the Peaceful Uses of Outer Space and other international organizations related to space research and peaceful uses of the results of space research for the development of mankind. The Government of the Slovak Republic also expressed support for the participation of Slovak research institutions in the projects performed on ISS. The creation of the Committee for Research and Peaceful Uses of Space in Slovakia was officially announced in document A/AC.105/752/Add.3.

2. The activities of research institutions from the Slovak Republic in the field of space research were internationally recognized by the General Assembly on 10 December 2001 by the Assembly's agreement for the Slovak Republic to become a full member of the Committee on the Peaceful Uses of Outer Space.

3. The following domestic projects or projects of international collaboration were performed during 2001 by research institutes of the Slovak Academy of Sciences and universities active in the field of space research.

1. **Space meteorology**

Project: **Satellite information applications for flood forecasting and monitoring support**

Institution in charge: **Slovak Hydrometeorological Institute, Bratislava**

4. In the framework of the cooperation with EUMETSAT, the Slovak Hydrometeorological Institute has started preparation work on a project aimed at the utilization of satellite data for the hydrological warning service. A working group was established including representatives of EUMETSAT cooperating and member States. It was given the following tasks, which are to be completed in the near future:

(a) Evaluate the current status of satellite data usage in the operational hydrological services of the countries involved in the project;

(b) Define the scope of the upcoming project, whose results should support flood forecasting and monitoring using data from meteorological satellites, with respect to the common needs of both cooperating and member countries of EUMETSAT;

(c) Determine a list of end products of the upcoming project and define, plan and schedule all research and development work.

5. Institutions participating in the working group include:

(a) EUMETSAT (administrative and scientific support of the four member countries (France, Germany, Italy and Switzerland));

(b) The Meteorological and Hydrological Service of Croatia (project member);

(c) The Hungarian Meteorological Service (project member);

(d) The Slovak Hydrometeorological Institute (project member);

(e) The Polish Institute of Meteorology and Water Management (project member).

6. The project will belong to the Satellite Application Facility (SAF) group of projects. The overall aim of the SAF projects is a better utilization of satellite data in various meteorological and hydrological applications and research. The benefits of the proposed project will be in the area of atmosphere and hydrosphere studies with the utilization of satellite measurements and satellite data assimilation in hydrology, in the development and enhancement of hydrological models and procedures used in the forecasting and monitoring of dangerous flood events.

7. The Slovak Hydrometeorological Institute organized the fourth EUMETSAT Central and Eastern European User Forum in Bratislava from 29 to 31 August 2001. The meeting was very successful.

8. The MSG/EUMETSAT/Slovak Hydrometeorological Institute Training Course for participants from Central and Eastern Europe was held in Bratislava from 6 to 8 March 2001. Scientific presentations concerned satellite systems, conceptual models, radiation sensing, the SAF concept, the MSG satellite and satellite imagery. These theoretical presentations were followed by practical exercises.

9. Slovakia was also active within the SAF Network Programme of EUMETSAT.

10. The satellite imagery from the Meteosat geostationary satellite and other satellites has been used continuously for more than 16 years by the Slovak Hydrometeorological Institute in its operational activities. The Institute uses Meteosat and other satellite data in its operational forecasting activities and research programmes. To retain this continuity, it is planned to use data from the MSG satellite after its launch.

2. Remote sensing

(a) Project: **National cooperative programme on assessment and monitoring of air pollution effects on forests**

Institution in charge: **Forest Research Institute, Zvolen**

Satellite-based thematic maps of changes in forest health conditions

11. The methodology for the detection of changes in the health conditions of the forests in Slovakia was developed based on Land Remote Sensing Satellite (Landsat) thematic mapper data. Classification was carried out from 1990 to 1996 and from 1996 to 1998 using a change detection algorithm. The results were processed in the form of thematic maps of forest damage changes in Slovakia on the scale 1:500,000. The output, a thematic map, is classified into six classes by z-scores.

Development of methodology for processing high-resolution satellite data

12. A methodology was developed for geometric correction, the classification of tree species composition, forest decline and change detection using the IKONOS satellite in a model territory in the Low Tatra Mountains. The results, based on spectral analyses of image data, showed only weak possibilities for classification of forest damage and tree species composition. Using object-oriented processing of image information, taking into account "inherent" image features such as colour, texture and form features, it is possible to carry out other research.

Creation of a library of spectral curves from satellite and aerial hyperspectral data for the classification of forest damage

13. A set of spectral measurements of healthy and damaged leaves of Norway spruce (*Picea abies*) and beech (*Fagus sylvatica*) was taken by the spectroradiometer LI-COR 1800. Analyses of the spectral data showed the possibility of separating not only healthy and damaged trees, but also initial damage classes of forest decline.

(b) Project: **Inventory, analysis and assessment of landscape changes by satellite data**

Institution in charge: **Institute of Geography, Slovak Academy of Sciences, Bratislava**

14. For the last three years, the research activities of the Institute of Geography of the Slovak Academy of Sciences in the field of remote sensing and GIS have been

concentrated on the field of inventory, analysis and assessment of landscape changes.

15. One of the most important achievements has been the development and practical application of a methodological approach to landscape change identification, analysis and assessment in the territories of four PHARE (programme to assist the applicant countries of central Europe in their preparations for joining the European Union) countries (the Czech Republic, Hungary, Romania and the Slovak Republic). The changes were identified at the national level from Landsat thematic mapper and multispectral scanner satellite images by application of the CORINE land cover databases for two time horizons, the late 1970s and early 1990s, at the second hierarchic level. Based on identified causality, the landscape changes were grouped into seven types: intensification of agriculture; extensification of agriculture; urbanization—industrialization; enlargement of mining or exhaustion of natural resources; afforestation; deforestation; and other anthropogenic effects. The results of the groupings were presented in the form of contingency tables and maps showing the spatial distribution of the changes.

16. The most pronounced changes in Slovakia were represented by a decrease in forest cover of 94,935 ha and that of heterogeneous agricultural areas of 18,451 ha; the enlargement of transitional woodland-scrub areas and urbanized areas were about 13,107 ha and 14,990 ha respectively.

17. The assessment of the identified changes through the driving forces—pressures—states—impacts—responses (DPSIR) framework was based on an analysis of relations between the environmental system and the human system. This was one of the tasks of the PHARE Topic Link on Land Cover Consortium, which included the Institute of Geography of the Slovak Academy of Sciences of Bratislava, the Romanian Geological Institute of Bucharest and HNIT Baltic of Vilnius and was coordinated by the GISAT company of Prague.

3. Space physics

18. Various activities relating to space physics are ongoing in Slovakia. They take place mainly at four institutions: the Institute of Experimental Physics of the Slovak Academy of Sciences in Košice, in cooperation with Technical University Košice, the University of P. J. Safárik in Košice and Technical University Zvolen; the Astronomical Institute of the Slovak Academy of Sciences in Tatranska Lomnica; the Geophysical Institute of the Slovak Academy of Sciences in Bratislava; and the Faculty of Mathematics, Physics and Informatics of Comenius University in Bratislava.

19. The research focuses on the dynamics of plasma and energetic particles within the Earth's magnetosphere and near its boundary regions, physical processes in interplanetary space and in the Sun, and cosmic rays and their modulation.

20. Of the activities that took place in 2001, there are at least three of special importance. They include the experimental activities and data analysis from instruments designed, constructed and tested by participating laboratories in Slovakia and have been working in space on satellites and on ISS.

(a) **Project:** **Analysis of energetic particle experiments on four satellites in the project Interball**

Institution in charge: **Institute of Experimental Physics, Slovak Academy of Sciences, Košice**

21. This project is based on an extensive data set, almost five years of continuous operation of energetic particle measurements by the DOK2 and DOKS devices on both main satellites Interball 1 and 2, as well as on subsatellites Magion 4 and 5, addressing various characteristics of ions and electrons of energies between ~20 keV and 600 keV in and near the boundaries of the magnetosphere. The main activities were devoted to analysis of angular distribution and energy spectra of electrons and ions within the magnetosheet, in the magnetotail, in auroral regions and in the region upstream from the Earth's bow shock. The mechanisms of particle acceleration and transport were studied using the data. The data sets are the most extensive obtained until now in space physics in Slovakia. There are detailed case studies, systematic statistical studies as well as comparative studies with other satellite measurements, for instance those from the polar satellite of the United States. The project is carried out in cooperation with several laboratories abroad.

(b) **Project:** **Measurement of energetic particles on Coronas-F**

Institutions in charge: **Institute of Experimental Physics, Slovak Academy of Sciences, Košice and Technical University, Zvolen**

22. The Coronas-F satellite, with a low-altitude polar orbit, was launched on 31 July 2001 from Plesetsk, Russian Federation. Its main objectives were studies of corpuscular and electromagnetic emission from the Sun and solar activity. One of the devices working on board the satellite is Solar Neutrons and Gammas (SONG), which was designed, constructed and tested at the Institute of Experimental Physics of the Slovak Academy of Sciences in cooperation with Moscow University. Measurements are running continuously with high temporal and energy resolution. The instrument provides data important for studies of space weather effects, for models of radiation near Earth, solar flares and non-stationary processes in interplanetary space and near the Earth (for example Forbush decreases in cosmic rays providing the possibility for comparison with ground-based cosmic ray measurements using neutron monitors).

(c) **Project:** **Monitoring of radiation on the International Space Station**

Institutions in charge: **Institute of Experimental Physics, Slovak Academy of Sciences, Košice and Geophysical Institute, Slovak Academy of Sciences, Bratislava**

23. On 27 November 2001, the first of the SCORPION measurement complexes was delivered by Moscow University to the Russian module of ISS. As the first participation of institutions in Slovakia, a stack of passive solid state detectors was installed on ISS in the framework of the SCORPION complex. Its objective is the measurement of secondary products created by primary cosmic rays and other constituents of corpuscular radiation within ISS. The evaluation of tracks will be done at the Institute of Experimental Physics of the Slovak Academy of Sciences after the stack returns to Earth in the first half of 2002.

24. Many more activities relating to space physics were carried out in Slovakia in 2001, such as the start of a project at the Geophysical Institute of the Slovak Academy of Sciences on the quantification of the solar wind-magnetosphere coupling, coordinated by the International Space Science Institute in Bern, Switzerland (modelling of magnetic storms in terms of variability in space weather); an initiative to network Lomnický štít neutron monitor measurements in real time (http://neutronmonitor.ta3.sk); the participation of Slovak scientists and technicians in international teams working in space physics on satellites and space probes (both data evaluation and the design of new instruments); the start of work on the multidisciplinary subject of the influence of selected physical parameters on the activities of people at airplane altitudes and at low orbits in space, being carried out jointly by the Military Hospital Košice and the Institute of Experimental Physics of the Slovak Academy of Sciences, Košice, as well as others.

4. Space biology and medicine

(a) Project: **Mechanisms of neuroendocrine, cardiovascular and metabolic adaptation to simulated microgravity**

Institutions in charge: **Institute of Experimental Endocrinology, Slovak Academy of Sciences, Bratislava and Faculty of Medicine, Lyon, France**

25. Head-down bed rest (HDBR) has been a model commonly used to simulate the effect of weightlessness. Studies of HDBR of various durations have been performed and have improved the knowledge of the influence of microgravity, mainly concerning alterations of the cardiovascular system. In our previous investigation during short space flight and HDBR, it was found that neuroendocrine and metabolic responses to various stressors in the same subject differ from those obtained under normal gravity. Prolonged space flights or stays on ISS require prediction of the responses of the human body to various stressors during the process of adaptation to weightlessness by using the results of observations in subjects exposed to simulated microgravity.

26. The overall objective of this proposal is to investigate neuroendocrine, cardiovascular, metabolic and immune responses to mental and somatic stressors acting by different mechanisms (metabolic, cardiovascular, physical) during HDBR of various durations simulating a stay in microgravity. Responses to stress stimuli are supposed to be determined during the pre-bed rest period and after various intervals of HDBR.

27. The results of these studies should lead to a new understanding of the relationship between circulatory, neuroendocrine and metabolic mechanisms involved in adaptive changes during microgravity and provide the means of compensating or accounting for undesirable developments.

28. Collaboration between the Institute of Experimental Endocrinology (IEE) of the Slovak Academy of Sciences and the Faculty of Medicine, Lyon, France facilitated the participation of the Institute of Experimental Endocrinology of the Slovak Academy of Sciences in the ESA project on the effects of exposure of human subjects to long-term bed rest (90 days). In addition to scientists from the ESA countries, research teams from the United States (NASA) and Japan (National Space Development Agency) also took part in this project. At the Institute of Experimental

Endocrinology of the Slovak Academy of Sciences, determinations of plasma and urinary catecholamines and their metabolites are in progress.

(b) **Project:** **Responses of the human body to different loads during long-term space flight on ISS (Endotest 2)**

Institutions in charge: **Institute of Experimental Endocrinology, Slovak Academy of Sciences, Bratislava and Institute of Biomedical Problems, Russian Academy of Sciences, Moscow**

29. The project aims to study the neuroendocrine, metabolic and cardiovascular responses of astronauts to different loads during long-term spaceflight and the adaptation process of physiological functions, in order to determine and prevent the possible negative effects of stays in space on the human body.

30. In our previous studies on Slovak astronauts during the "Štefánik" programme, significant differences were found in neuroendocrine reactivity to various loads during short-duration space missions compared to pre- and post-flight conditions: an exaggerated response of stress hormones during physical exercise and mental stress and a diminished contra-regulatory response to the lowering of blood sugar, which is the essential fuel for the brain. These alterations might be due to a counter-charge of the neuroendocrine system to an acute change of gravity and it would be necessary to elucidate the chronic effects of zero gravity.

31. In a majority of previous studies during long-lasting space missions, the data describing the levels of hormones and metabolites and the parameters of body fluid balance were obtained in steady-state conditions. Functional loads were presumably used to study changes in the cardiovascular system (such as changes in heart rate, blood pressure and peripheral vascular resistance) and no data were collected on the changes in levels of hormones and metabolites, which allow one to determine the level of load, the tolerance interval to load, the adaptability to load and the body's ability to cope with the physical and mental demands of life on board ISS with enhanced potential for acute, unexpected situations, which may have a stressogenic influence on the astronaut's body.

32. The present project aims to determine dynamic function tests for the evaluation of physiological responses in the pre-flight period, at the beginning of space flight, after four months' space flight and during re-adaptation after landing. These include neuroendocrine, circulatory and metabolic responses to physical exercise, insulin sensitivity, mental performance and associated neuroendocrine and cardiovascular activation during all periods and responses to orthostatic tests during pre- and post-flight periods.

33. The results obtained will expand knowledge of physiological adaptations to space flight and will evaluate the ability of the human body to respond properly to different stress situations. This integrated insight will enable the prediction of potential problems and the planning of adequate responses to situations that might occur during long-term missions.

34. The agreement on collaboration between the Institute of Experimental Endocrinology of the Slovak Academy of Sciences and the Institute of Biomedical Problems of the State Research Centre, Russian Academy of Sciences, was signed

on 27 April 2001. Using PLASMA-03 appliances, neuroendocrine responses to work can be studied, and metabolic and physical loads can be determined with the participation of scientists from both institutions. The Institute of Experimental Endocrinology of the Slovak Academy of Sciences will also participate in regular investigations of the health status of astronauts before flight, during short- or long-term space flights and during the post-flight period. This research is ongoing.

(c) **Project:** **Influence of simulated microgravity on human postural responses to sensory stimulation**

Institution in charge: **Institute of Normal and Pathological Physiology, Slovak Academy of Sciences, Bratislava**

35. The aim of this project was to investigate the role of altered sensory interaction in postural instabilities after space flight to test "reweighting" of vestibular and somato-sensory inputs by postural responses to galvanic vestibular and muscle vibratory stimulation.

36. The balance-test data of a Slovak astronaut, recorded after a short space flight, were analysed in relation to transient postural instability after landing. The results confirmed that sensory interaction altered in microgravity is probably responsible for the post-space flight balance instability. On the basis of these results, an improvement of the galvanic balance test was developed, which allows estimation of the altered weight of vestibular input in human balance control during re-adaptation to the Earth's condition.

(d) **Project:** **Changes in functions of the neuroendocrine system during exposure to simulated microgravity and hypergravity**

Institutions in charge: **Institute of Experimental Endocrinology, Slovak Academy of Sciences, Bratislava, Institute of Animal Biochemistry and Genetics, Slovak Academy of Sciences, Ivanka pri Dunaji and Institute of Measurement Science, Slovak Academy of Sciences, Bratislava**

37. The proposed project aims to carry out a series of experiments with rats exposed to hypokinesia (tail-suspension hypokinesia, restriction of mobility) for various time periods, with blood sampling during the hypokinesia using a canula and the determination of plasma levels of hormones, neurotransmitters and metabolites. At selected time-intervals and in isolated organs and tissues, it is proposed to measure the content of neurotransmitters, hormones, production of hormones, activity of enzymes involved in the production of neurotransmitters, and the expression of genes for coding these enzymes. The response of the neuroendocrine system (changes of catecholamine, corticosterone, prolactin and growth hormone) will be determined. The results will be used for the evaluation of the capacity of the body to overcome several stress loads.

38. Similar observations are proposed for a group of animals exposed for a short time to hypergravity (using the centrifuge device in the Institute of Animal Biochemistry and Genetics of the Slovak Academy of Sciences) simulating a gravity load at the start or landing of spacecraft (6-8 G). Studies are also proposed of

adaptation to hypergravity of 2 G for a period of two weeks, simulating the process of post-flight re-adaptation.

39. The results of these experiments are important for the understanding of mechanisms of changed activity of the neuroendocrine system and metabolic processes observed in human subjects and experimental animals after space flights, and also to distinguish between the specific effects of microgravity and hypergravity during the landing and post-flight re-adaptation to gravity conditions on Earth.

40. In 2001, studies concentrated on the construction of an item of electronic equipment for multiple blood withdrawal with telemetric control from small experimental animals exposed to hypergravity in a centrifuge. A pair of rats was placed in a box rotating in a centrifuge with a maximum 6 G gravitational overloading. The equipment consisted of a telemetric transmitter (placed outside the room of the centrifuge) and receiver. Both transmitter and receiver were equipped with microcomputers. A miniature receiver, connected to a control and power unit operated by the microcomputer was placed in the rotating box. Four active rotor stepping motors drove four pairs of syringes. Three pairs of syringes were used to actively withdraw blood, and one pair was used to remove the non-active liquid from the tubing. It was also possible to measure the instantaneous gravitational force using an accelerometric transducer placed near the box with telemetric data transmission. This telemetrically regulated blood sampling allows the study of selective effects of hypergravity during centrifugation. It can be also used for the study of microgravity effects in the animal's body during space flights on ISS.

(e) Project: **Study of osteodystrophies, egg-shell formation abnormalities and reproductive and adaptive processes in the Japanese quail under hypodynamy, hypergravity and microgravity**

Institution in charge: **Institute of Animal Biochemistry and Genetics, Slovak Academy of Sciences, Ivanka pri Dunaji**

41. This project represents a continuation of successful research on Japanese quail embryogenesis in weightlessness on board the Mir orbital space station. The objective of this project was to obtain new data on the effect of hypodynamy, hypergravity and microgravity on quail, which could be used in the future as a higher heterotrophic link in autonomous closed ecosystems during long-term stays of humans on orbital and planetary stations.

42. The method of rearing Japanese quail chicks under simulated conditions of weightlessness and hypodynamy from the first day after hatching was modified. The adaptability of one-, two- and three-day-old quail chicks to two weeks' continuous hypodynamy was studied in three replicates using this method. Because no differences in the results achieved were found, the decision was made to proceed with an experiment testing the post-embryonic development of quail hens in hypodynamy from the ages of 2 to 56 days. Differences between the development of hypodynamy-reared individuals in comparison with those kept under control conditions were studied using morphological and physiological methods.

43. The knowledge obtained could be applied in the study of the early post-natal development of Japanese quail under microgravity conditions. The stationary model

for rearing Japanese quail under simulated weightlessness represents a real alternative to rearing quail in microgravity generated using centrifugation. However, a centrifuge of the required size cannot be built because of limited room on board a space station in the near future.

(f) **Project:** **Accumulation and persistence of cytogenetic damage induced by radiation and other factors of space flight**

Institution in charge: **Institute of Cell and Molecular Biology, Faculty of Sciences, Šafárik University, Košice**

44. This project is based on preceding studies in which the accumulation of latent cytogenetic damage in slow proliferating tissues (liver, kidney) in the course of continual exposure of animals to ionizing radiation was demonstrated. The aim of this project is to study, in model experiments, the possibility of induction and accumulation of the latent damage by other space flight factors such as hypergravitation, vibration or hypokinesis. From the point of view of long-term space flights, the study of the possibility of trans-generational transfer of the latent damage to the progeny of exposed individuals may be of special importance.

45. Discussion has begun on cooperation with scientists from the Institute for Low Temperature Physics of the Ukraine Academy of Science, concerning deoxyribonucleic acid (DNA) structure analyses in the exposed individuals and their progeny.

46. Latent damage was studied in the liver of male rats irradiated by gamma rays, as well as the progeny of these rats. Latent damage manifested itself after stimulation of cell division by partial hepatectomy. After partial hepatectomy, in the regenerating liver of progeny, cytogenetic changes similar to those in the irradiated fathers were noted (decrease in mitotic activity, increase in chromosomal aberration frequency, and so forth), but the extent of changes was lower in comparison with the parent generation.

South Africa

[Original: English]

1. Introduction

1. In October 1957, a telecommunications engineer in Johannesburg, South Africa, using a home-made aerial, tracked Sputnik-1 by tuning in to the radio signals it was transmitting and using the Doppler effect to calculate its closest approach to South Africa. During that same year, the United States invited South Africa to participate in tracking the satellite it planned to launch in 1958, which had been designated International Geophysical Year. The emphasis moved rapidly from tracking to receiving scientific data and has included tracking, telemetry and command services to over 400 launches in the past four decades. The current business contracts of the Hartebeeshoek Satellite Applications Centre link it to the national space agencies of many countries, as well as to the world's leading aerospace companies.

2. Astronomy

2. The South African Astronomical Observatory (SAAO), with its main observatory situated at Sutherland in the Northern Cape Province, is the national optical observatory. The Southern African Large Telescope (SALT) is being built at this desert-like site, with partners from Germany, New Zealand, Poland, the United Kingdom and the United States. This will be the largest single telescope in the southern hemisphere, with a hexagonal mirror array 11 metres across. Good progress was made with construction work in 2001.

3. The SALT Collateral Benefits Plan has been developed to address the intention that SALT should contribute to the development of human resources in the fields of science and technology. A major part of the activity at SAAO is geared to delivery of the Plan, specifically in the areas of educational empowerment, public outreach and science awareness, science education visitor centres and SALT as an African facility. The SALT web site is at <http://www.saao.ac.za/salt/>.

4. SAAO hosts a geodynamic observatory funded by the GeoForschungsZentrum in Germany. It is equipped with a superconducting gravimeter as part of the Global Geodynamic Project.

5. A new Infrared Survey Facility completed its first year of activity in 2001, observing the Magellanic Clouds and the central regions of the Milky Way galaxy. The Facility is a collaboration between South African and Japanese astronomers to survey the sky at infrared wavelengths. The facility consists of a dedicated 1.4-metre telescope and simultaneous, three-channel imager for specialized surveys of the southern hemisphere sky in the infrared bands.

6. A new 0.75-metre robotic photometric telescope completed its first year of automated operation in 2001. The project is a collaboration among SAAO, the University of Cape Town and the University of South Africa. This telescope has opened the possibility of access via e-mail to observations taken in Sutherland for astronomers working elsewhere in Africa. In this regard, there is increasing emphasis on engagement with other African countries. SAAO has recently hosted visiting scientists from Egypt, Ethiopia, Uganda, Zambia and Zimbabwe. The SAAO web site is at <http://www.saao.ac.za>.

3. Radio astronomy

7. The Hartebeeshoek Radio Astronomy Observatory, near Johannesburg, South Africa, is the only major radio observatory in Africa. It was built originally by NASA to track many early, unmanned space probes. In 1975 it was converted to a radio astronomy observatory. The observatory has been involved in space geodesy research using Very Long Baseline Interferometry for some years. As the only radio telescope capable of this in Africa, Hartebeeshoek is in considerable demand. GPS and a satellite laser ranging system are also operated as further techniques in this programme.

8. Some other programmes are in continuum radiometry, spectroscopy, pulsar timing and providing practicals and courses for university students. The observatory's web site is at < http://www.hartrao.ac.za>.

4. Satellite applications

9. The Satellite Applications Centre at Hartebeeshoek provides products and services related to the space industry and its applications. Expertise is available in geo-information projects and solutions; tracking, telemetry and command; and ground segment services.

10. A limited number of examples will serve to illustrate work done or in progress.

11. In September 2001 electrical and civil works for a new Ka-band antenna, key to the new Spaceway Satellite Tracking Station, were completed.

12. Agrimage Pty, the Satellite Applications Centre's first commercial spin-off, continued to expand its services in precision farming.

13. Preparations for the new X-band antenna, which will arrive in early 2002, were completed. This 5.4-m, X-band, full-motion reception antenna, with a fully automated control system, will be used primarily for reception of remote sensing imagery and telemetry. For more information on the antenna, see the Satellite Applications Centre web site at <http://www.sac.co.za>.

5. Sunsat

14. On 19 January 2001 the last communication with SUNSAT, South Africa's first satellite, occurred. Postgraduate electrical engineering students of the University of Stellenbosch built this satellite. In the 696 days between its launch and its last communication, this project exceeded all its original goals, which were:

(a) To demonstrate high-resolution imaging not before considered possible with a satellite of this size and cost;

(b) To cooperate, as OSCAR-35, with the amateur radio and amateur satellite communities worldwide, contributing new standards in the field;

(c) To stimulate challenging research and technology development at the graduate student level;

(d) To foster valued international ties in the science and engineering community;

(e) To promote science, engineering and technology among the schoolchildren of South Africa. For more information on SUNSAT, see the web site at <http://www.sunsat.ee.sun.ac.za/>.

6. Space physics research

15. Some work done by the University of Natal (Durban) is mentioned as an example of space physics research done in 2001 by South African universities.

(a) An automatic VLF (very low frequency) station at Sanae in the Antarctic has been established. The operation is controlled from the university in Durban and 24-hour, quick-look data is returned to Durban on a daily basis;

(b) The Space Group at the University of Natal, collaborating with Stanford University and the Danish Meteorological Institute, was involved in the Conjugate Sprites experiment. Photometer measurements were made at Sutherland in the

Northern Cape Province and, in the conjugate region, from the Pic du Midi Observatory in the Pyrenees, France;

(c) Conjugate VLF radio experiments between Bornholm, in the Baltic Sea, and Marion Island were done. The University of Natal Geospace Physics Group conducted the expedition to Marion Island and the Space Physics group at Eotvos University, Budapest, did the recordings at Bornholm;

(d) Work was done on the design of a VLF experiment for the second South African scientific satellite.

7. Concluding remark

16. An exciting initiative which has come from the South African space science community in 2001 is a proposal to form an African institute of space science to bring together the presently disparate elements of space science in South Africa. It is intended to serve as a source of vision and strategy for the development of space science on the continent of Africa. The concept has been embraced by a number of potential stakeholders in South Africa and beyond. It is now being tested in a broader forum.